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RESEARCH ARTICLE

An orchid (Orchidaceae)-rich area recommended for preservation in Novosibirsk Region, Russia

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Abstract

The spatial distribution of 14 species of the orchid family (Orchidaceae) was studied at the left bank of the Koynikha River (Iskitimskiy District, Novosibirsk Region, Russia). Four species are listed in the Russian Federation Red Data Book, four are listed in the Novosibirsk Region Red Data Book. The number of individual plants is sufficient to ensure the long-term viability of each red-listed orchid population. What is apparently one of the largest populations of *Cypripedium macranthos* in the region is described (up to 5,000 individuals). Some of the orchids discovered require further study, namely interspecific hybrids of *Dactylorhiza* and *Gymnadenia* and distinctive floral developmental morphs of *Platanthera*. Applying the international criteria for allocation of an "Important Plant Area", we nominate a new one for South Siberia. Based on the analysis of plant species composition of protected areas in Novosibirsk Region, we conclude that *in situ* preservation of orchids in the region is overall insufficient. It is therefore necessary to organize a new protected area "Orchid Zapovednik" in the category of "botanical Zakaznik" on 335 hectares with an explicit floral diversity conservation mandate and long-term orchid population monitoring.

Keywords

Rare species, orchids, protected areas (PAs), plant biodiversity conservation, Red Data Book, Important Plant Area (IPA)

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Introduction

Orchidaceae is one of the most diverse families of angiosperms and also among the most threatened. The main reasons for the decline in wild orchids in the temperate regions of the world, such as North America and Eurasia, are human-induced destruction of their habitats, wholescale transformation of ecosystems, harvesting of plants and flowers from the wild, and a decrease in population fitness due to inbreeding (Fay 2018). It is well known that orchids are not highly competitive, have small populations, and narrow geographic distributions (Vakhrameeva et al. 2014).

Preservation of viable orchid populations requires a thorough understanding of their biology. Most species are highly specialized with respect to their pollinators and have complex interactions with multiple organisms in the early stages of their life cycle (e.g., entomophily, deep symbiotic relationship with soil fungi, tiny seeds, long periods of time spent underground before emergence, and parasitic traits) (Efimov 2010). It appears that the fungi forming mycorrhiza with orchids and ensuring the germination of their seeds and normal development, have a much wider geographic distribution than the orchids themselves (Hadley 1970). In general, we can explain the rarity of many orchid species by their complex ecology (Vakhrameeva et al. 2014).

Due to vital nutrients supplied by mycorrhiza, Orchidaceae can persist easily in soil with low nitrogen availability. In fact, low nitrogen availability reduces competition with eutrophic grasses and forbs, so many orchids prefer nutrient-poor environments (Bakin 2014). Joint growth of a few orchid species in the same habitat in temperate regions may be explained by their preference for carbonate-rich substrates (calciphily) (Bakin and Fardeeva 2012), probably explained by competitive exclusion from other substrates rather than by an innate need for calcium. Some orchids are found in specialized habitats, e.g., morainal hills or oligotrophic bogs.

In Russia, the co-occurrence of different orchids has been noted since the early 19th century. For example, the Vyshnevolotsky-Novotorzhsky moraine hill complex in the vicinity of Ilyinskoe village, Tver Region, has 17 species of orchids recorded over 200 years of observations (Pushay and Dementyeva 2007). In the Ivanovo Region, the Utkinsky wetland complex is home to 16 species, of which five are listed in the Russian Federation Red Data Book (Golubeva et al. 2007). The Khamitovo wetland in Chelyabinsk Region has locations with 11 (Atlyanskoe) and 7 (Khamiat) species (Kulikov and Lagunov 2013). In the Republic of Gorny Altay, local concentrations of orchid species are known to exist in the valleys of the Multa, Kuragan, and Kucherla Rivers (12 species at each site), near Chemal (11), near the mouth of the Chulyshman river (10), Manzherok Lake (10), and the Mena River (10) (Gerasimovich 2012). In the lowland West Siberia, nine orchid species were found in bogs near Kourak (Novosibirsk Region) and Kokuy (Kemerovo Region) (Lashchinsky 2009). Kislukhinsky Zakaznik (nature refuge in terms of Sobolev et al. 1995) in Altaysky Kray has eight listed species of terrestrial orchids, of which six are included in the Red Data Book (Silantyeva 2019).

Most orchids in Russia are considered rare and are included in regional and federal Red Data Books and in the IUCN Red List as well. Sixty percent of all species are listed in the national Red Data Book (2008). In Omsk and Kursk Regions, all species are listed in their regional red lists (Omsk 2015, Kursk 2017). Novosibirsk Region, where this study was conducted, contains 30 orchid species in its flora (Krasnoborov et al. 2000, Gerasimovich 2018, GBIF.org 2020), of which eight are listed at the federal level and 12 are regionally listed (Red Data Book of Novosibirsk Region 2018) as vulnerable or endangered species.

There has been no systematic research on the vulnerability of rare and endangered orchids on protected areas in the Region. The main goal of this study was to record species occurrences and spatial configuration of populations of orchids at a unique recently discovered site along the left bank of the Koynikha River in the Novosibirsk Region. In addition, an attempt is made to classify this territory based on international criteria as an "Important Plant Area" and to recommend an appropriate protection regime.

Material and methods

The authors spent three vegetation seasons (2017–2019) in obtaining detailed field records from the target area in the Iskitim District of the Novosibirsk Region, Russia (Fig. 1). All plant names are given in accordance with the Flora Sibiriae (1987) as well as more recent taxonomic treatments of particular genera (Efimov et al. 2016). *Cypripedium macranthos* Sw. is named according to Averyanov (2000).

Field data were collected and recorded using GPS receivers, remotely sensed imagery, and topographic maps. Public cadastral data was used together with plant locations in a NextGIS QGIS package. This allowed us to estimate the overall area covered by plant populations. To assess the biodiversity value of the research area, we used the criteria for identifying Important Plant Areas (IPAs) by Anderson (2002) and IUCN… (2004), adapted for the Altay–Sayan Ecoregion (Artemov et al. 2007, Artemov et al. 2009, Buko et al. 2009). Although Novosibirsk Region lacks regional endemics needed to apply criteria A and B, we believe, following the authors of this adaptation, that presence of a species from the Red Book of Russian Federation and/or regional Red List with Categories 1–3 (Endangered, Decreasing Number, Rare) is sufficient to be nominated an area as IPA according to these criteria. Criterion C based on the EUNIS landscape classification can be applied to Novosibirsk Region because it was originally developed for the whole of South Siberia (Artemov et al. 2007, Artemov et al. 2009).

The datasets were generated in the iNaturalist and GBIF platforms based on verified data from the Flora of Russia project implemented under the auspices of the Moscow State University Herbarium (Seregin et al. 2020a, 2020b).

To evaluate conservation needs for the orchid species, the authors analyzed the regional register (cadaster) of protected areas (PAs) and the results of the monitoring of natural monuments of regional significance conducted in 2010–2013.

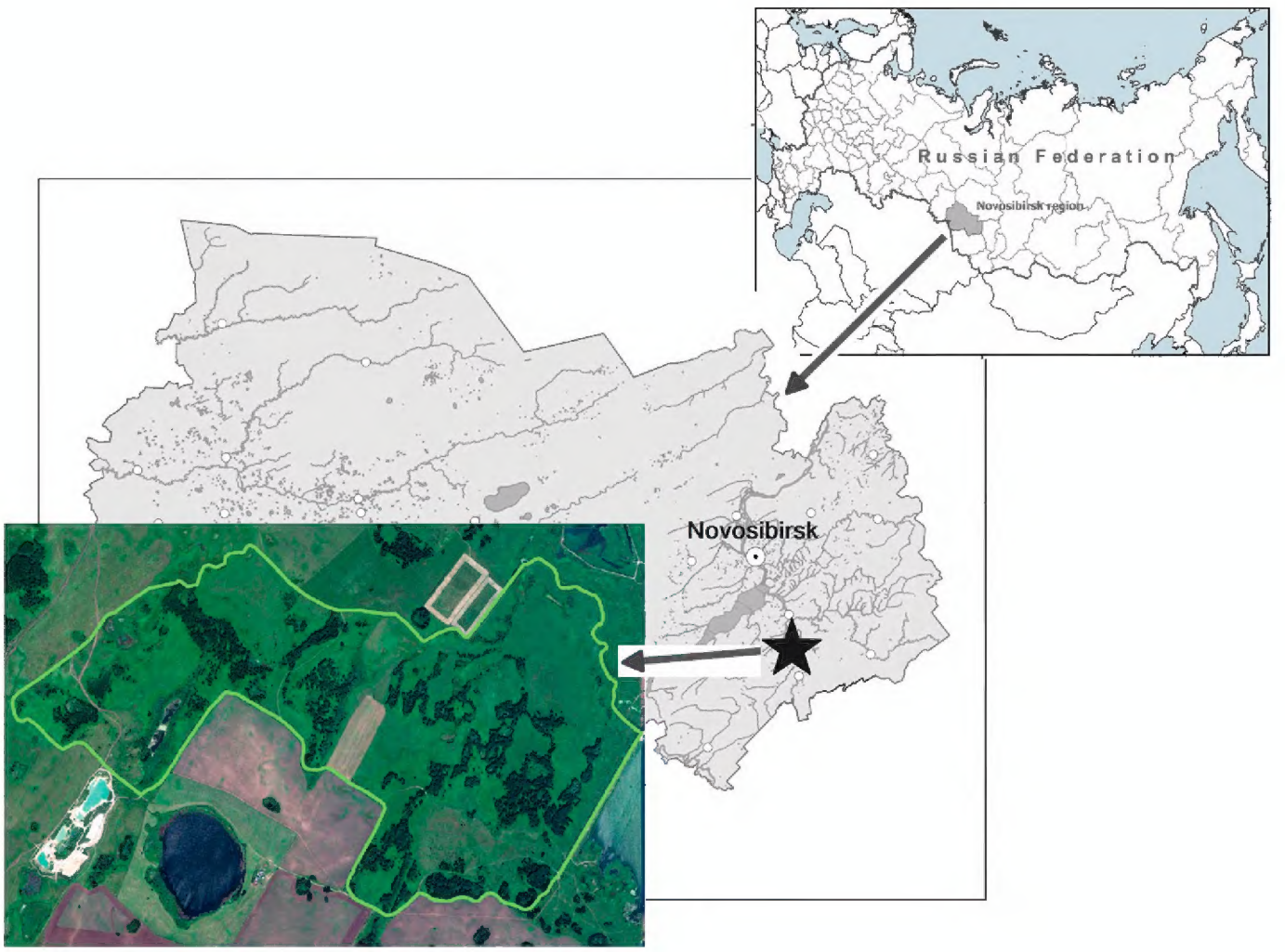

Figure 1. Location of the study area.

Results and Discussion

The studied area is characterised in detail below, in the section Description of the Important Plant Area. This site was first discovered by Yuri Panov, a local biology teacher and environmental activist in the town of Linevo, Iskitim District. He compiled a list of 13 species of Orchidaceae in an area of approximately 40 ha and informally called it an "orchid zapovednik." According to his observations, in 2014 a ground fire generated by local farmers burning their fields damaged many populations. A number of botanists were invited to survey the area after this event to assess the damage and, more importantly, to conduct a scientific inventory.

Lyudmila Gerasimovich (2018), an orchid expert from Novosibirsk, gave the first scientific description of orchids of this local area. She provided detailed morphological descriptions of local *Cypripedium* species: *C. calceolus*, *C. macranthos* and *C* × *ventricosum* and underlined the importance of rapid and radical conservation measures to save this locally unique place. She also published a list of the 13 species known to that date: *Dactylorhiza cruenta* (O.F. Muel.) Soó, *D. incarnata* (L.) Soó, *D. fuchsii* (Druce) Soó, *D. maculata* (L.) Soó, *Epipactis helleborine* (L.) Crantz, *E. palustris* (L.) Crantz, *Herminium monorchis* (L.) R. Br., *Gymnadenia conopsea* (L.) R. Br., *Platanthera bifolia* (L.) Rich., *Orchis militaris* L., *Cypripedium calceolus* L., *C.*

macranthos Sw., *Cypripedium* × *ventricosum* Sw. Almost simultaneously, Eugenia Gatilova (2018) published an article that provided more exact locational data for *C. calceolus*, *C. macranthos* and *Orchis militaris* near Linevo. In 2017–2019 the authors of this paper found additional large populations of orchids on over 300 ha of land.

Diversity of Orchidaceae Species in the Study Area

The most up-to-date list of orchid species of the study area is shown in Table 1. We utilized the iNaturalist platform to store photos and locational data for every observation and in a format compatible with Global Biodiversity Information Facility (Ueda 2020) (Fig. 2). According to Efimov et al. (2016) we consider *Dactylorhiza cruenta* to *D. incarnata* and exclude *D. maculata* from the list of orchid species.

The species listed in Table 1 appear to be well established, naturally occurring populations. The most numerous are *C. macranthos*, *C.* × *ventricosum*, *Epipactis palustris*, *Dactylorhiza fuchsii* and *D. incarnata*.

An interesting discovery was a few populations of *C.* × *ventricosum*, which is a rare form and never very numerous. Until recently, *Cypripedium* × *ventricosum* Sw. was not considered a distinct species (Ivanova 1987, Krasnoborov et al. 2000). Today, most plant taxonomists accept a hybridogenic origin of the species (Averyanov 1999, Knyazev et al. 2000, Vakhrameeva et al. 2014, Plantarium… 2020). Interest-

Table 1. List of Orchidaceae species in the target area and the number of their individuals.

Species name	iNaturalist/GBIF, number of observations	Individual plants (estimate)
Cypripedium calceolus* L.*,* Lesser yellow lady's-slipper	12	100–200
Cypripedium macranthos* Sw.*,* Large-flowered lady's-slipper	53	3000–5000
Cypripedium* × *ventricosum* Sw. Bloated lady's-slipper	14	150–200
***Dactylorhiza fuchsii* (Druce) Soó** Fuch's keyflower, common spotted orchid	37	Many
***Dactylorhiza incarnata* (L.) Soó** Scarlet keyflower, early marsh orchid	22	300
***Epipactis helleborine* (L.) Crantz.** Broadleaf helleborine	14	200
***Epipactis palustris* (L.) Crantz.** Marsh helleborine	22	Many
***Gymnadenia conopsea* (L.) R. Br.** Fragrant orchid	14	300–500
***Herminium monorchis* (L.) R. Br.** Musk orchid	8	300

Species name	iNaturalist/GBIF, number of observations	Individual plants (estimate)
Neottia nidus-avis* (L.) Rich.* Bird's nest orchid	4	30–50
Orchis militaris* L.*, * Soldier orchid	13	100–200
***Platanthera bifolia* (L.) Rich.** Two-leaved orchid	20	200-300
Single finds		
Species name	**References, iNaturalist/GBIF**	
***Dactylorhiza salina* (Turcz. ex Lindl.) Soó**	Ueda 2021a	
***Dactylorhiza viridis* (L.) R.M. Bateman, Pridgeon & M. W. Chase (*Coeloglossum viride* (L.) Hartm.)** Frog orchid	Ueda 2021b	

Notes: * Red Data Book of the Russian Federation (2008), ** Red Data Book of Novosibirsk Region (2018).

Figure 2. A–C Distribution of threatened and rare orchid species within the borders of the suggested Important Plant Area.

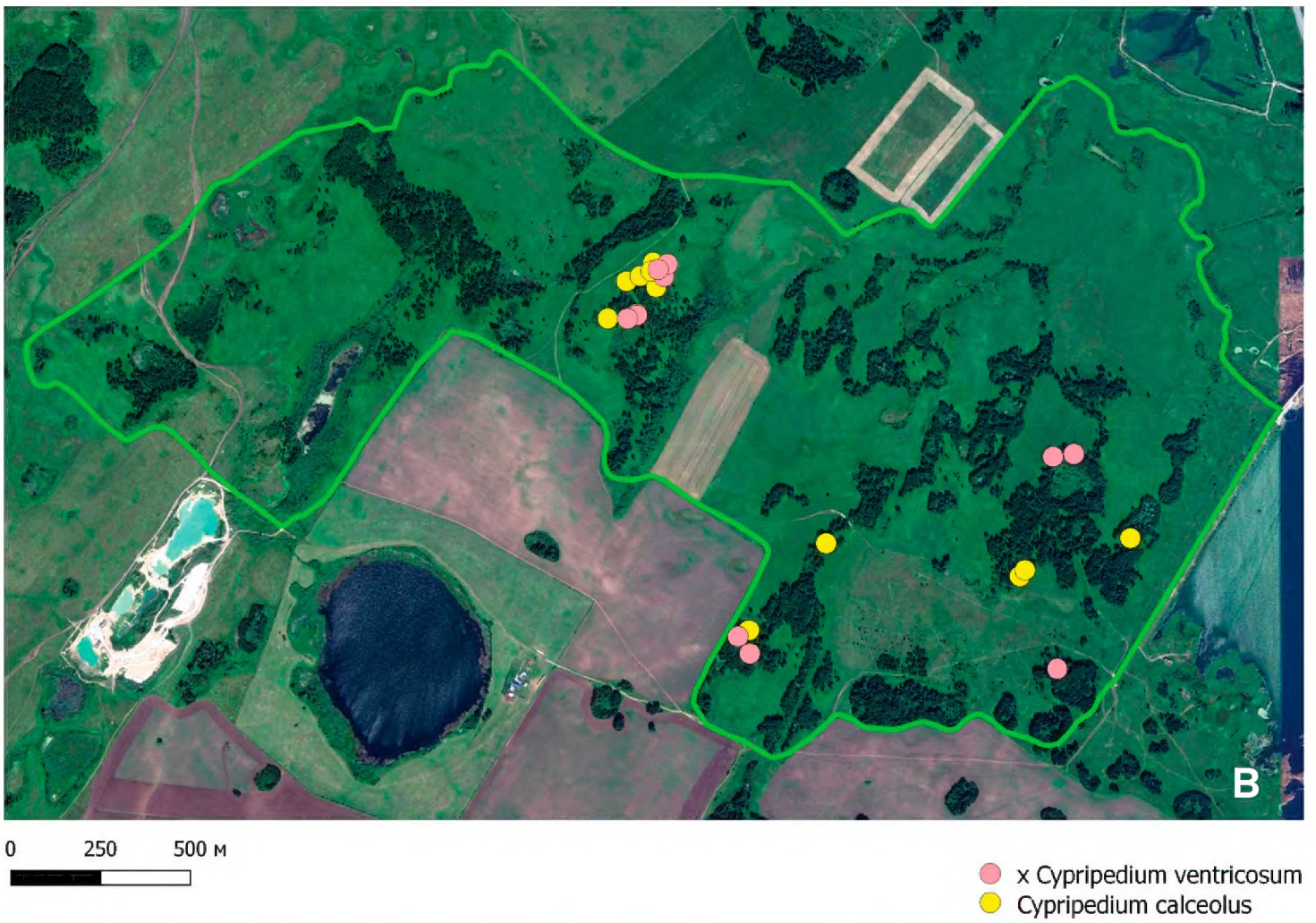

Figure 2. Continued.

ingly, while *Cypripedium* × *ventricosum* is a federally red-listed taxon, it is mistakenly not recognized as such at the regional level (Red Data Book… 2018). It is listed in 16 other Russian regions and is found in 12 zapovedniks (strict nature reserves).

The *Cypripedium calceolus* and *C. macranthos* seed reproduction is low, but much higher in the latter and is apparently pollinated by the former producing F1 hybrids of *C.* × *ventricosum* (Knyazev et al. 2000). Thus, the parent taxa of *C. calceolus* and *C. macranthos* become evolutionary significant objects for protection, as they enable production of the third taxon (Filippov and Andronova 2011).

In our study area, *Cypripedium* × *ventricosum* appears to show a very diverse coloration of the corolla, high aesthetic value, and vigorous vegetative reproduction (Fig. 3).

Within the IPA boundaries, orchids concentrate in areas with low or intermediate human disturbance. *Cypripedium* species prefer to occupy the ecotone between forest and the open areas, although *C.* × *ventricosum* and *C. macranthos* may also occur in meadows. *C. calceolus* and *Neottia nidus-avis* are found primarily in wooded areas. *Orchis militaris* are typically found in meadows.

During our observations, we found a few unusual forms, morphologically similar to *Gymnadenia*, *Platanthera* and *Dactylorhiza*. These genera exhibit interspecific and even intergeneric hybridization (Efimov 2012, Stace 2019) and produce distinctive

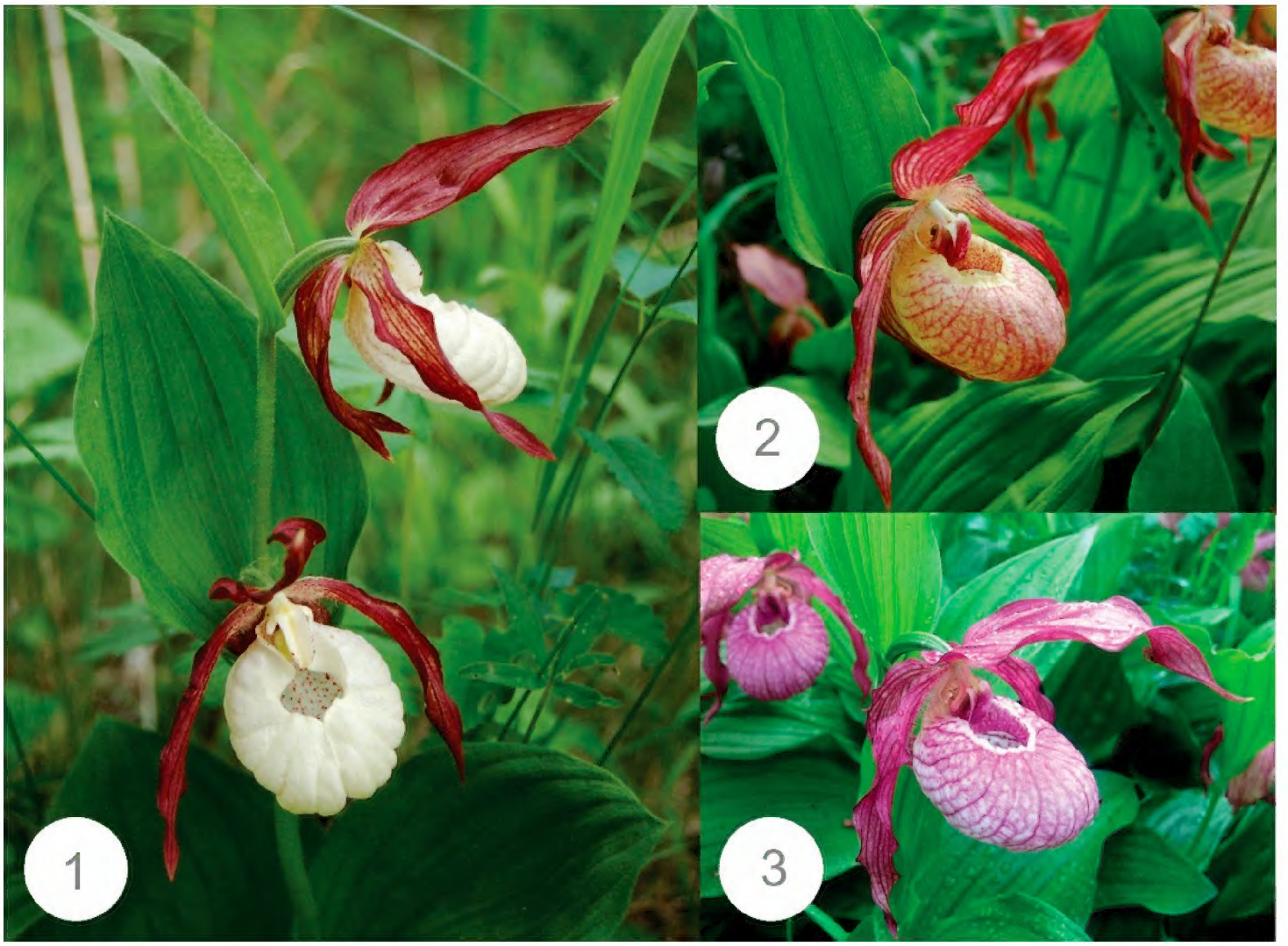

Figure 3. Variety of color of the corolla of Cypripedium × ventricosum within the boundaries of the target area (varieties: **1** – white, rare, **2** – orange, rare, **3** – common). Photos by the authors.

floral developmental morphs. *Dactylorhiza* and *Gymnadenia* hybrids were described as a hybrid genus × *Dactylodenia* (Garay & H.R.Sweet (*Dactylogymnadenia* Soó)).

Richard Bateman suggested (by personal communication) that most of the morphological features of the plant in Fig. 4 (3a, 3b) indicate 'a typical example of a hybrid between *Gymnadenia conopsea* and either *Dactylorhiza fuchsii* or *D. maculata*. The shape and dimensions of the labellum, spur and lateral sepals all indicate such an origin, as does the dark purple staining of the pollinia. The only problem with this determination is that it lacked *Dactylorhiza*-style markings on its labellum. The markings can be faint, but they are usually inherited by such hybrids in some form'. Both of the unusual forms of *Platanthera bifolia* (Fig. 4; 4, 5) appear to be distinctive floral developmental morphs (Cronk 2009), one of which may belong to pseudopeloric morph, in which the labellum is poorly differentiated and is similar to, but not identical with, the outer perianths segments (Bateman 1985).

Summing up, almost half of all known orchid species in the Novosibirsk Region were detected within the limit of our small suggested IPA. The area contains four species listed in the regional and four in the national Red Data Books, and probably the largest occurrence of *Cypripedium*, by number of individual plants, in the Region. Some orchids appear to be interspecies or intergeneric hybrids, unusual morphs.

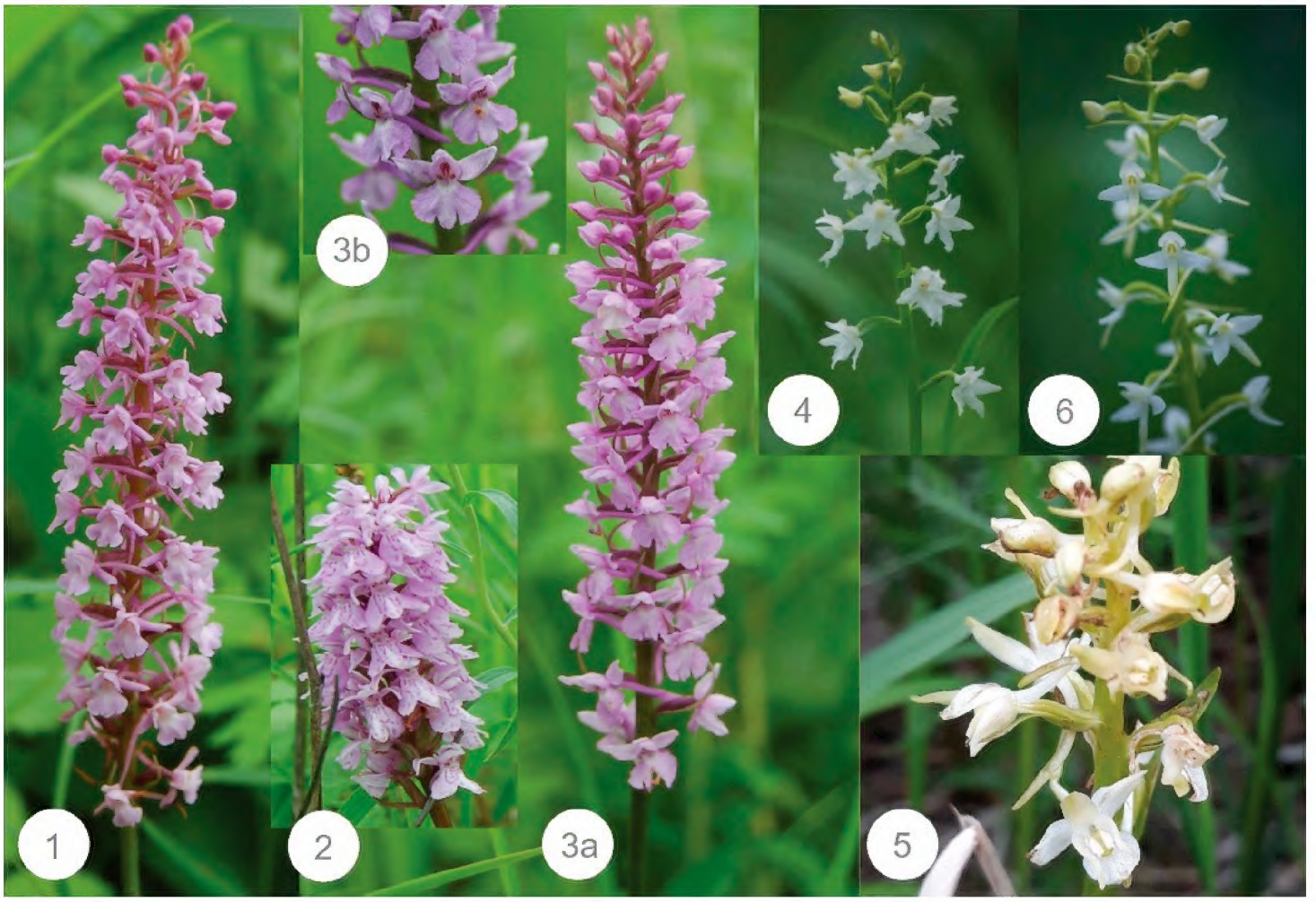

Figure 4. Hybrid and parent forms of orchids in the study area: **1** — *Gymnadenia conopsea*, **2** — *Dactylorhiza fuchsii*, **3A** — *Dactylorhiza* × *Gymnadenia*, **3b** — *Dactylorhiza* × *Gymnadenia* (large); **4** — distinctive floral developmental (pseudopeloric) morph of *Platanthera bifolia*, **5** — distinctive floral developmental morph of *Platanthera bifolia*, **6** — *Platanthera bifolia*. Photos by the authors (1, 2, 3a, 5) and Zakir Umarov (3b, 4, 6).

Description of the Important Plant Area

This temperate zone IPA is unique not only within the Region, but also has national significance for Russia. We applied the criteria for botanical evaluation developed for South Siberia to assess its fitness for inclusion in an international database (Artemov et al. 2007, Artemov et al. 2009, Buko et al. 2009).

1. Name: IPA Orchid Zapovednik.

2. Location: Iskitim District, Novosibirsk Region, Russian Federation.

3. Geographic coordinates (N, E, S, W points respectively): 54.475 N, 83.227 E; 54.466 N, 83.347 E; 54.458 N, 83.338 E; 54.469 N, 83.295 E.

4. Area: 335 ha.

5. Habitat types. In accordance to the second tier EUNIS typology, the following habitats were identified in this territory.

C (inland surface waters): C2 – surface running waters (0.2% of the area).

D (mires, bogs and fens): D5 – sedge and reed beds, without free-standing water (1.8%).

E (grasslands and lands dominated by forbs, mosses or lichens): E2 – mesic grasslands (E2.2, E2.5, E2.6, E2.7), E3 – seasonally wet or wet grasslands, E5 – woodland fringes and clearings and tall forb stands, E7 – sparsely wooded grasslands (55.2%).

F (heathland, scrub and tundra): F9 – riverine and fen scrubs (3.8%).

G (woodland, forest and other wooded land): G1 – broad-leaved deciduous woodland (G1.A), G5 – lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice (32.9%).

I (regularly or recently cultivated agricultural, horticultural and domestic habitats): I1 – arable land and market gardens (5.8%).

J (constructed, industrial and other artificial habitats): J1 – built-over areas, J5 – ponds and other artificial wetlands (0.5%).

6. Brief description of the territory. The research area is located 600 m west of Linevo Town and 2 km south of Shibkovo village. In the north it is bordered by the Sibantracite Factory, on the east by the M52 Federal Highway, in the south by the Novosibirsk Elektrode Factory dam and an unpaved road, and in the west by a private field and an active limestone quarry. The area is long exploited and is formally listed as agricultural land and forest land (Iskitim forestry unit).

The territory stretches along the left side of the Koynikha River valley (the River is 86 km long) that joins the Berd River, which in turn is a tributary to the Ob River. In terms of relief, the area is primarily flat or slightly undulating plain with loess and lacustrine deposits (Map Factory... 2015). The prevailing soils are leached chernozem, gray forest, loess, and partially carbonated loams. In the forest-steppe region of West Siberia, the territory belongs to the northern part of the forest-steppe along the right bank of the Ob and northwestern cluster of the forest-steppe of the Ob-Tom interfluve piedmont plain (Kuminova 1963; Makunina 2016).

We suppose that the high orchid species richness and the abundance of plants in this area are due to availability of limestone-rich light loams relatively free of large forbs and a locally high water table. Meadows and forests predominate, with some wetlands. A few spots are occupied by halophytic meadows, which is not typical for this generally well-drained forest-steppe landscape along the right bank of the Ob.

Forests are represented by a series of small stands of forb-and-grass rich birch forests with *Brachypodium pinnatum* (L.) Beauv., *Heracleum dissectum* Ledeb., *Sanguisorba officinalis* L., *Pulmonaria mollis* Wulfen ex. Hornem., and *Filipendula ulmaria* (L.) Maxim. Near the middle of these patches, some wetlands appear with *Calamagrostis canescens* (Web.) Roth., *Phragmites australis* (Gav.) Trin. ex Steud., and marsh sedges.

Open areas between forests are mainly grass-forb rich dry meadows with some steppe elements dominated by *Poa angustifolia* L., *Calamagrostis epigeios* (L.) Roth s.l., *Galatella biflora* (L.) Nees, *Filipendula vulgaris* Moench., *Peucedanum morisonii* Besser ex W.D.J. Koch. There are also a few post-forest successional meadows with scattered birch trees. These are dominated by *Brachypodium pinnatum*, *Cirsium heterophyllum* (L.) Hill, *Galatella biflora* (L.) Nees, *Filipendula ulmaria*, *Plantago maxima* Juss. ex Jacq., *Sanguisorba officinalis*, and *Trollius asiaticus* C.A.Mey. Small solonchak meadows have distinct flora with some regionally rare plants, e.g., *Saussurea salsa* (Pall.) Spreng., *Limonium gmelinii* (Willd.) Kuntze, *Carex distans* L., etc. The wettest habitats are occupied by species-poor reed marshes with *Phragmites australis*, surrounded by wet meadows with *Filipendula ulmaria* as the key dominant.

7. Botanical value of the study area. The local forest communities have vigorous populations of three *Cypripedium species*, as well as *Epipactis helleborine*, *Orchis militaris*, and *Neottia nidus-avis*. Near the ecotonal forest-meadow boundary, *Dactylorhiza fuchsii* and *Platanthera bifolia* are common. The steppe meadows have *Dactylorhiza*, *Herminium monorchis*, *Gymnadenia conopsea*, and occasionally *C. macranthos*. Post–forest meadows (meadows that appeared on the site of the forest after logging) have populations of *Epipactis palustris*, *C. macranthos*, and *Dactylorhiza incarnata*. The wet solonchaks are home to *Dactylorhiza*, *Herminium monorchis*, *Gymnadenia conopsea*, as well as *C. macranthos*.

8. Alignment with IPA criteria.

Criterion A

A (ii) *Cypripedium calceolus*, *C. macranthos*, *Orchis militaris*, *Stipa pennata* L.

Criterion B

Ophioglossum vulgatum L., *C. ventricosum*, *Neottia nidus-avis*, *Dactylorhiza incarnata*, *D. fuchsii*, *Epipactis palustris*, *E. helleborine*, *Platanthera bifolia*, *Gymnadenia conopsea*, *Herminium monorchis*.

Criterion C

Not applicable, but the area has a high diversity of habitats, some of which are regionally rare.

9. Local use and threats. Currently, the territory is used moderately. Some of it is ploughed or used for hay production. There are no commercial timber harvesting

but little precludes this from happening. The heaviest impacts are from hay harvesting and periodic spring fires, some of which spread from neighboring farms. Some orchids, especially *Cypripedium*, are collected for bouquets by local people.

Overall, 32 land parcels fit inside the study area and are legally assigned to the Shibkovo village council of the Iskitim Municipal District of Novosibirsk Region. There are two parcels allocated to the clay quarry (2 and 1.9 ha); furthermore, there are two power lines bisecting the area (0.9 km and 1.9 km) and the Novosibirsk-Cherepanovo fiber-optic line along its own protected land corridor 2 km in length. There are 15 parcels on 23 ha of forestland managed by the Iskitim forestry unit. The rest of the area is agricultural land, mainly Closed Joint Stock Company Shibkovskoe (until 2004), which is currently in the process of being redistributed to other landowners.

10. Status of species and habitats. The natural communities of the IPA are in a good condition. Populations of the rare species are stable. Monitoring shows mainly weather-driven fluctuations from year to year.

11. Legal protection. Absent, except through listings of threatened taxa in Red Data books.

12. Recommendations for conservation measures. A botanical Zakaznik or a natural monument should be established on this territory to prohibit any management regime that could drastically alter the existing mosaic of habitats. In particular, spring burns of forest or meadow vegetation should be controlled. Anthropogenic disturbance, including hay harvesting, may be important in keeping the area open

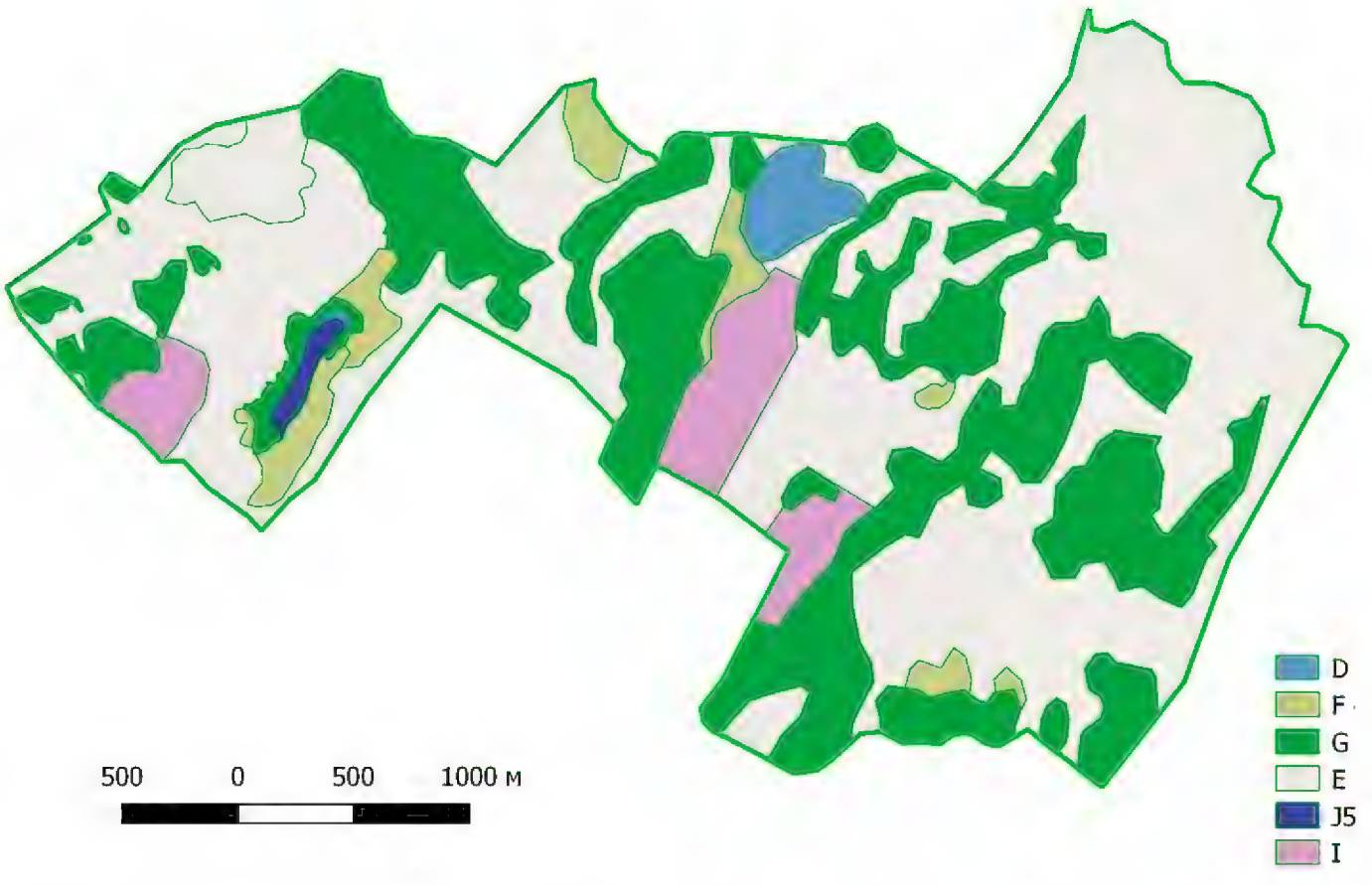

Figure 5. Map of the main habitats in the studied area. Codes are explained in the text.

and arresting the succession, and so to create habitats suitable for orchids. It may be good to encourage late season hay harvesting to keep the meadows in good condition for orchids. No fertilizers, herbicides or insecticides should be used. Public recreation should be reasonable. It is also desirable to conduct semi-stationary monitoring to study population dynamics of all orchid species in the area. Nature trails can be established around the periphery to highlight the area to the local public and visiting students. A cadastral assessment of protected natural areas of Novosibirsk Region (State inventory of protected areas. Environmental Inspectorate 2020, Protected areas of Russia 2020) and an inventory of natural monuments (Vesnina et al. 2010a, 2010b, 2010c, 2011a, 2011b, 2011c, 2011d, 2013, Belozertseva et al. 2012, Kolosova et al. 2018) suggest a lack of sufficient protection of Orchidaceae in preserves, including all threatened species. Many species are faced with probable extirpation (Dubynin 2020a). We recommend creation of a protected area on the basis of the assessed IPA (Dubynin 2020b).

Conclusion

The 335 ha research area on the left–bank of the Koynikha River in the Novosibirsk Region contains 14 species of Orchidaceae, some of which have surprisingly large local numbers in the region. We believe that this warrants national recognition for protection in Russia, regional recognition and inclusion to the Novosibirsk Region ecological network of protected areas (in terms of Pazhenkov et al. 2005). The populations of most species are vigorous, disturbance is low, and some interesting hybrids and morphs were found. The area corresponds to South Siberia criteria for an IPA. There is a potential for future scientific research and educational program development. The protection of orchids within a regional Zakaznik or another form of PA is required, with federal or regional status.

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